Concerns and Solutions for CO₂ A/C Systems for Compact Vehicles

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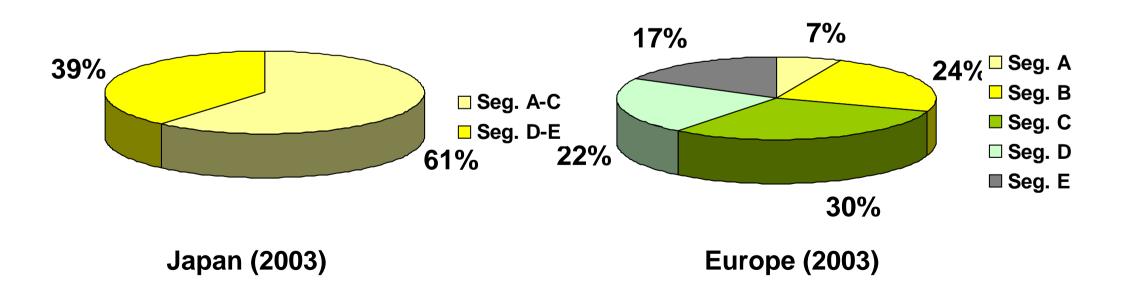
- Requirements to commercialize alternative
- Vehicle trend
- Climate conditions
- Problem for compact vehicles
- Power comparison of CO2 and R134a
- Reduction of compressor power consumption
- Power consumption trend for CO2
- Summary

Considerations on Prior to Commercialization

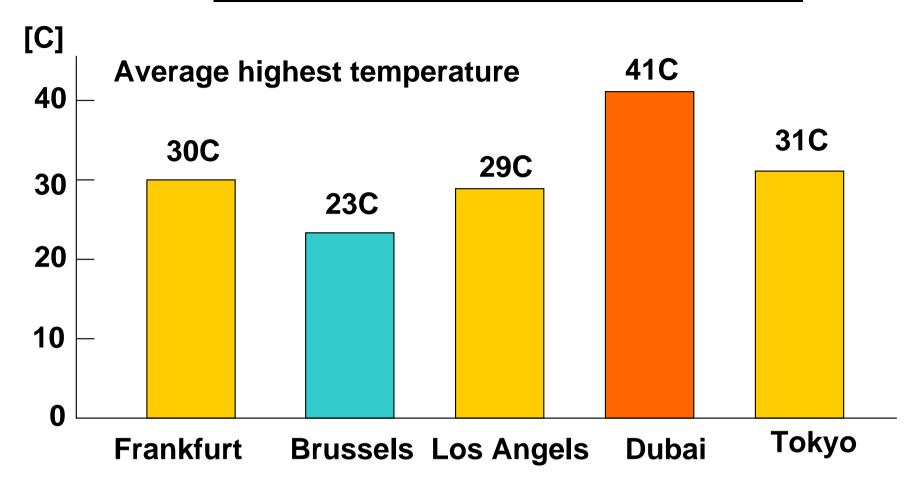
- Environmental Benefit
 Indirect & Direct Global warming Impact
- Cooling Performance
- Efficiency and Energy Usage
- Quality, Costs, Weights
- Safety, Serviceability
- Fitness to vehicles (from mini to small cars)
- Fitness to regional climate condition

Vehicle Trend

- Compact vehicles (segment A-C) occupy about 60% of the market in Europe and Japan
- The share of compact vehicles would increase due to fuel economy regulation



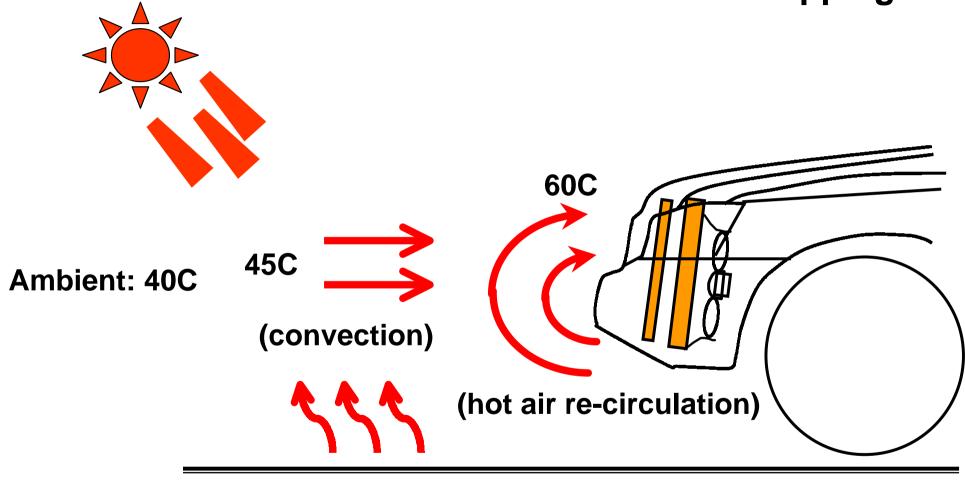
Climate Conditions



CO2 A/C system should exhibit comparable performance to HFC-134a under the use of compact cars and the most severe climate conditions

Problem for Compact Vehicle

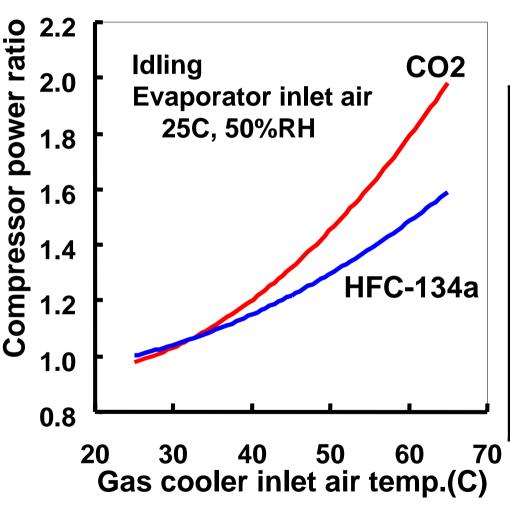
Gas cooler inlet air conditions at vehicle stopping



The Ground Temperature: 65C

The gas cooler inlet air temperature rise is about +20C due to "convection" and "hot air re-circulation"

Power Consumption Comparison of CO₂ and HFC-134a

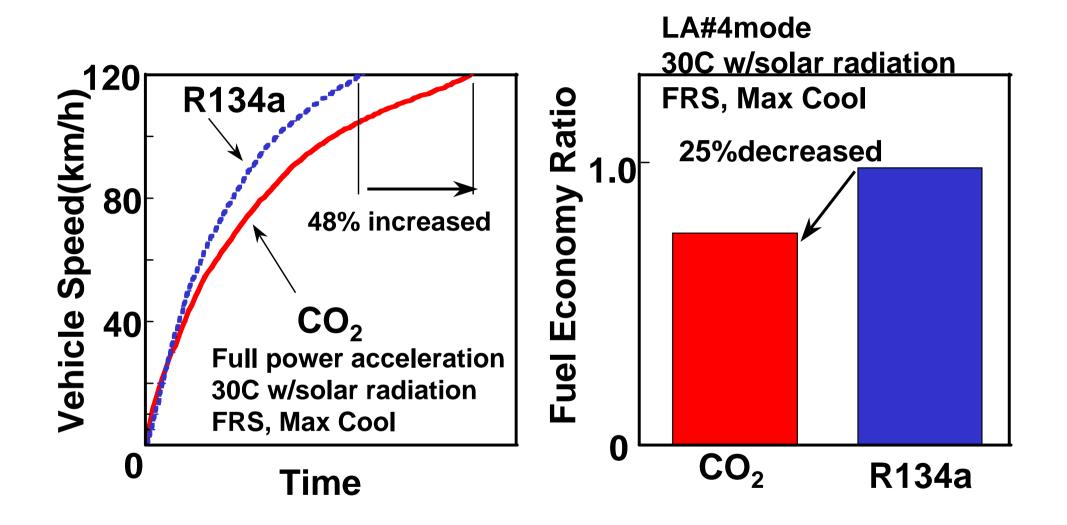


Specifications of A/C components (for compact vehicles 1.0L)

	CO2	HFC-134a
Compressor	Variable	Variable
	21cc/rev	85cc/rev
	(efficiency 85%)	(efficiency 65%)
Gas cooler	W500	W500
/Condenser	xH325xD16	xH325xD16
Evaporator	W199	W199
	xH231xD38	xH231xD38
Internal Heat Exchanger	16x2000	-

CO2 system has a large power consumption rise by the temperature rise of gas cooler inlet air

Acceleration - Fuel Economy



In CO₂ system, the increase in compressor power consumption has a major impact on vehicle performance

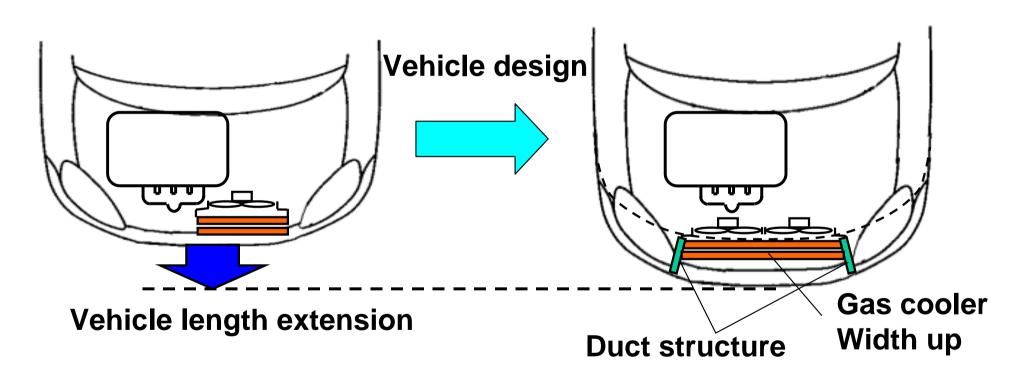
Reduction of Compressor Power Consumption (1)

Evaporator inlet air: 40C, 60%RH **Cooling performance=3.3kW (constant)** 1.4 Compressor power ratio (R134a=1) Gas cooler inlet air temp. for CO2 1.2 60C Ambient temp. +20C 8.0 55C Ambient temp. +15C 0.6 Gas cooler size up 0.4 0.2 0 400 600 800 1000 Gas cooler width size (mm)

Reducing air temperature of gas cooler and Increasing size of gas cooler are necessary

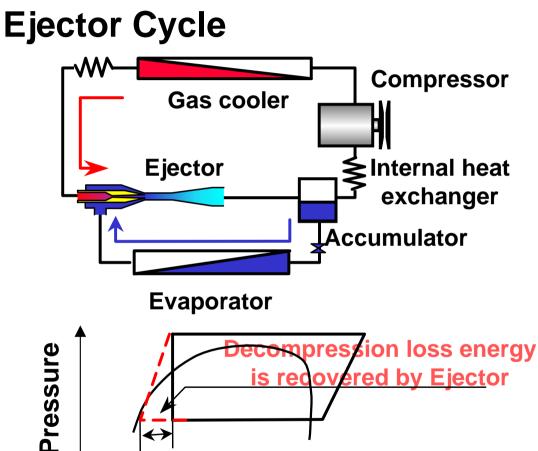
Concern for Vehicle Design

Enlargement of Gas cooler & Reduction of Hot air by Duct Structure

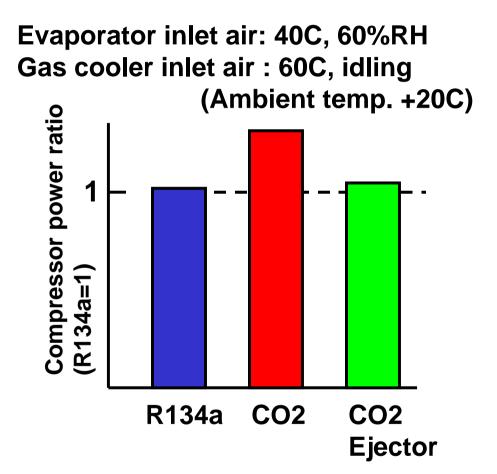


Extension of vehicle length is significant influence especially on compact vehicle design

Reduction of Compressor Power Consumption(2)

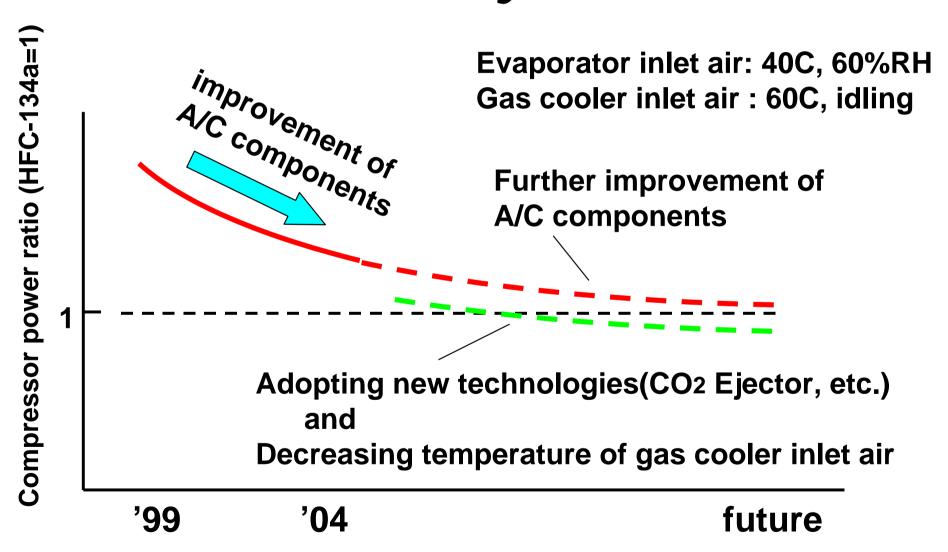


Enthalpy



- New approach to Efficiency equivalent to 134a system
- The system is more complicated than normal CO2 system

Power Consumption Trend for CO₂ System



Summary

To introduce CO2 A/C system to the various market of the world

The technological issues still remains;

A/C system design:

- Further improvement of A/C Systems and Components (Component's efficiency, Ejector system etc.)

Vehicle design:

- Decreasing the front air temperature rise (Duct structure)